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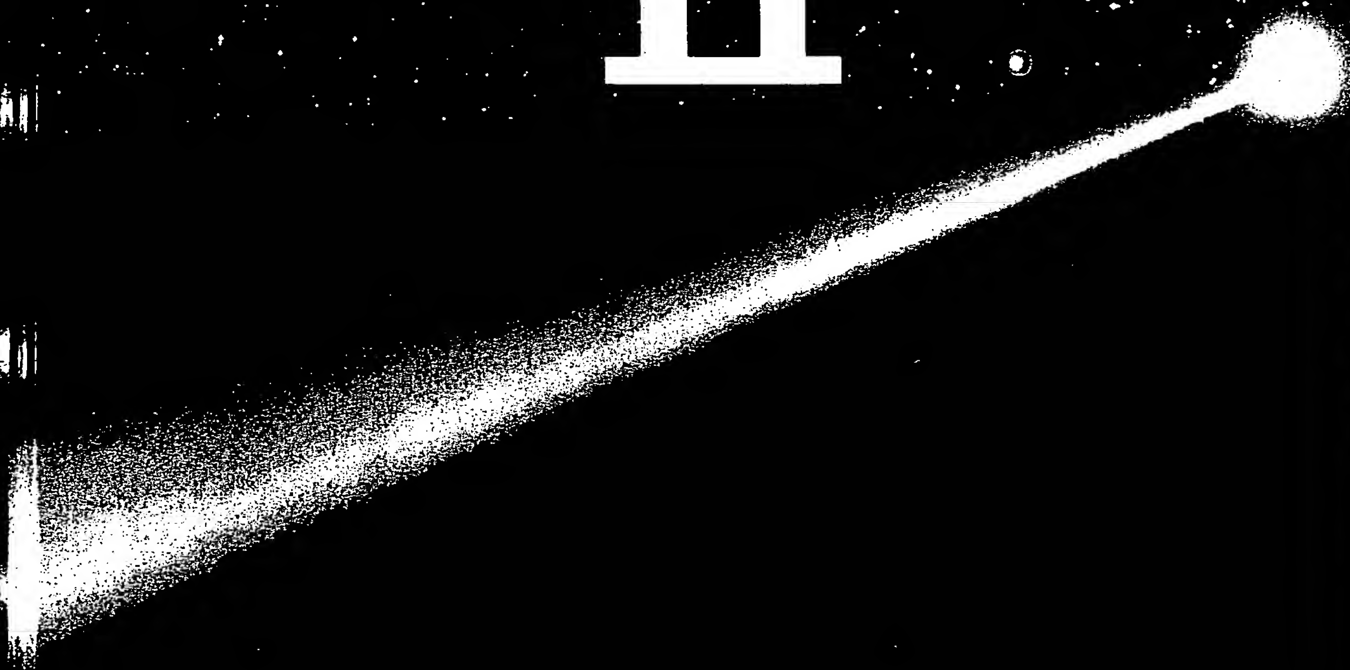
HANDBOOK OF OPTICS

DEVICES, MEASUREMENTS, & PROPERTIES

• SECOND EDITION •

VOLUME

II



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tolerance for molded aspherics is determined by the alignment of the mold halves. A common specification is 4 to 6 μm, although 3 to 4 μm is possible.

7.6 MONOLITHIC LENSLET MODULES

Monolithic lenslet modules (MLMs) are micro-optic lenslets configured into close-packed arrays. Lenslets can be circular, square, rectangular, or hexagonal. Aperture sizes range from as small as 25 μm to 1.0 mm. Overall array sizes can be fabricated up to 68 × 68 mm. These elements, like those described in the previous section, are fabricated from molds. Unlike molded glass and plastic lenses, MLMs are typically fabricated on only one surface of a substrate, as shown in the wavefront sensing arrangement of Fig. 9. An advantage of MLMs over other microlens array techniques is that the fill factor, which is the fraction of usable area in the array, can be as high as 95 to 99 percent. Applications for MLMs include Hartman testing,[20] spatial light modulators, optical computing, video projection systems, detector fill-factor improvement,[22] and image processing.

There are three processes that have been made used to construct MLMs.[22] All three techniques depend on using a master made of high-purity annealed and polished material. After the master is formed, a small amount of release agent is applied to the surface. In the most common fabrication process, a small amount of epoxy is placed on the surface of the master. A thin glass substrate is placed on top. The lenslet material is a single-part polymer epoxy. A slow-curing epoxy can be used if alignment is necessary during the curing process.[23] The second process is injection molding of plastics for high-volume applications. The third process for fabrication of MLMs is to grow infrared materials, like zinc selenide, on the master by chemical vapor deposition. Also, transparent elastomers can be used to produce flexible arrays.

MLMs are advertised[24] to be diffraction-limited for lenslets with NA < 0.10. Since the lens material is only a very thin layer on top of the glass substrate, MLMs do not have the same concerns that molded plastic lenses have with respect to birefringence and transmission of the substrate. For most low-NA applications, individual lenslets can be analyzed as plano-convex lenses. Aspheres can be fabricated to improve imaging performance for higher NAs. Aspheres as fast as NA = 0.5 have been fabricated with spot sizes about twice what would be expected from a diffraction-limited system. The residual error is probably due to fabrication imperfections observed near the edges and corners of the lenslets.[25]

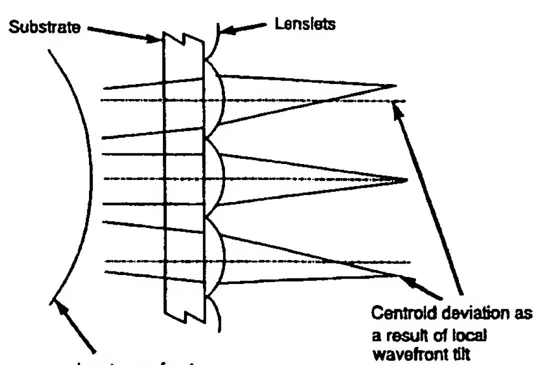
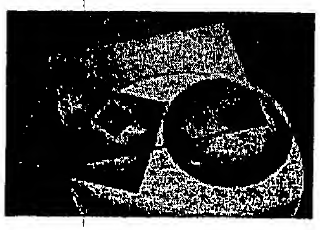


FIGURE 9 Monolithic lenslet modules (MLMs) configured for wavefront sensing.[28]

PCV Fresnel Lenses, Conical Groove Design



[Specification Table | Helpful Literature | Product Matrix | Technical Images]

A Fresnel lens replaces the curved surface of a conventional lens with a series of concentric grooves, molded into the surface of a thin, lightweight plastic sheet. The grooves act as individual refracting surfaces, like tiny prisms when viewed in cross section, bending parallel rays in a very close approximation to a common focal length. Because the lens is thin, very little light is lost by absorption. Fresnel lenses are a compromise between efficiency and image quality. High groove density allows higher quality images, while low groove density yields better efficiency (as needed in light gathering applications). In infinite conjuate systems, the grooved side of the lens should face the longer conjugate.

Fresnel lenses are most often used in light gathering applications, such as condenser systems or emitter/detector setups. Fresnel lenses can also be used as magnifiers or projection lenses; however, due to the high level of distortion, this is not recommended.

Specification Table

Focal Length Tolerance	±5%
Thickness Tolerance	±40%
Transmission	92% from 400-1100nm
Maximum Service Temperature	176°F
Refractive Index	$1.49n_d$

Products

[Quotation Request | Non-US Pricing Info | Quantity Pricing]

	Description	Size H x L (inches)	Effective Size (inches)	E.F.L. (inches)	C.T. (inches)	Grooves per in.	Stock Number	Price*	
BUY	FRESNEL NEG LENS 14.5" DIA	14.5" Dia	13.2" Dia	-8.4	.11	50	NT46-396	$155.70	BUY
BUY	FRESNEL NEG LENS 18.5" DIA	18.5" Dia	18.0" Dia	-18	.11	143	NT46-397	$260.50	BUY
BUY	FRESNEL NEG LENS 6.7 X 6.7"	6.7" x 6.7"	6.0" Dia	-3	.06	100	NT46-395	$57.40	BUY
BUY	FRESNEL NEG LENS ASPH 2 X 2	2.0" x 2.0" **	1.3" Dia	-.85	.06	200	NT46-394	$21.10	BUY

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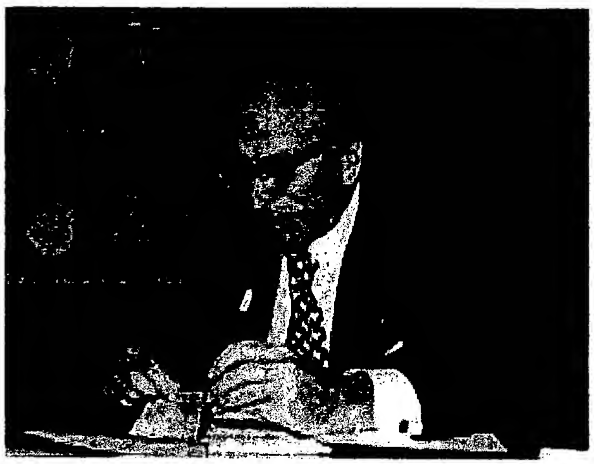
About Holography

History

History

Holography dates from **1947**, when British/Hungarian scientist Dennis Gabor developed the theory of holography while working to improve the resolution of an electron microscope. Gabor, who characterized his work as "an experiment in serendipity," coined the term hologram from the Greek words holos, meaning "whole," and gramma, meaning "message." Further development in the field was stymied during the next decade because light sources available at the time were not truly "coherent" (monochromatic or one-color, from a single point, and of a single wavelength).

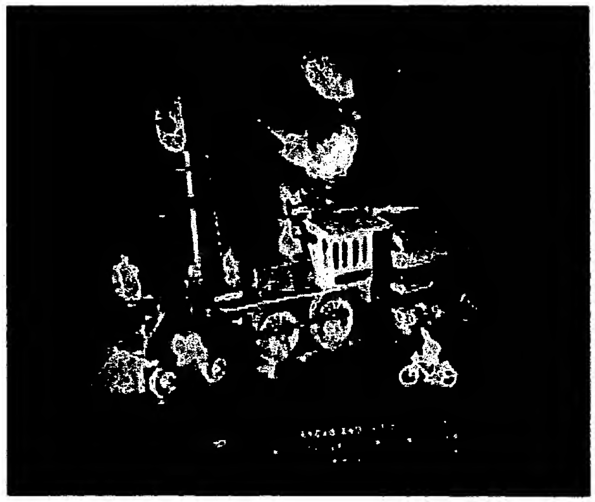


Dr. Dennis Gabor signs a copy of the Museum of Holography's
inaugural exhibition catalogue, "Through The Looking Glass," during his 1977 visit to the museum. (Photo by Paul D. Barefoot)

This barrier was overcome in **1960** with the invention of the laser, whose pure, intense light was ideal for making holograms.

In **1962** Emmett Leith and Juris Upatnieks of the University of Michigan recognized from their work in side-reading radar that holography could be used as a 3-D visual medium. In **1962** they read Gabor's paper and "simply out of curiosity" decided to duplicate Gabor's technique using the laser and an "off-axis" technique borrowed from their work in the development of side-reading

hologram of 3-D objects (a toy train and bird). These transmission holograms produced imag s with clarity and realistic depth but required laser light to view the holographic image.



"Train and Bird" is the first hologram ever made with a laser. This pioneer image was produced in 1964 by Emmett Leith and Juris Upatnieks at the University of Michigan only fouryears after the invention of the laser